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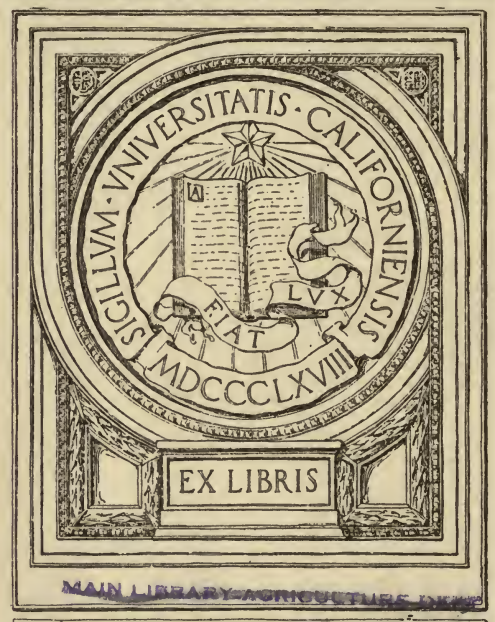

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DEPARTMENT OF AGRICULTURE,
NEW SOUTH WALES.

SCIENCE BULLETIN, No. 20.

March, 1921.

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Dairy Factory Premises and Manufacturing Processes:

The Application of Scientific Methods to their Examination.

L. T. MacINNES, Dairy Expert, and H. H. RANDELL, Assistant to Biologist.

Workers in the respective branches of Economic Science covered by this series of Science Bulletins will receive such of them as may be of use in their special branches of study upon application to the Under Secretary and Director, Department of Agriculture, Sydney.

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Dairy Factory Premises and Manufacturing Processes:

The Application of Scientific Methods to their Examination.

THE manufacturer of dairy produce has always some trouble to contend with, for milk and its products lend themselves to rapid deterioration, especially through bacterial agencies. It was with a view to minimising such troubles—by presenting to those engaged in the industry such information as might be gained from scientific and practical investigations on the spot—that the scheme of examining butter factories and the manufacturing processes carried out therein was initiated and approval obtained for the services of an officer of the Biological Branch of the Department of Agriculture to be placed at the disposal of the Dairy Branch. Apart from the ordinary every-day things that are always awaiting solution, we have what might be classed as seasonal epidemics, such, for instance, as the mould infection with which a great many factory managers had to contend some two summers ago, and the effects now being felt of an extremely dry season. These influences need special inquiry as they arise. The present series of investigations, however, does not specially deal with these epidemic troubles, but is confined to those that form part of the daily routine of certain factories inspected.

In the first case to be dealt with we have effects arising out of old and faulty premises badly situated from a sanitary point of view; in other cases it had been noted that the choicest brand of butter marketed showed deterioration, more or less marked, whenever it was held in cold storage for any considerable length of time. The causes of this deterioration in quality have been traced by means of our investigations, and satisfactory remedial measures taken.

As it is intended to commence this series of articles with the results obtained from an old bacterially contaminated factory, it is considered advisable to end it by way of contrast with those from one of the most modern—a factory built on the latest sanitary lines, where fresh air and sunlight have been recognised as the greatest of germicides and freely admitted accordingly.

Some ten years ago the Alstonville Co-operative Dairy Company had trouble with the quality of the butter then being manufactured, and an officer of the Dairy Branch investigated the matter and successfully used atmospherically exposed plates to trace the origin of the infection causing the deterioration, thereby enabling the company to remedy the matter. Knowing the value of arriving at and locating causes of deterioration by means of bacteriology, a scheme was worked out early last year whereby whatever came in contact with the dairy produce after its arrival at the factory until it was placed on the market, could be systematically examined and the results compared. The general adoption by the New South Wales dairy companies of the practice of pasteurising cream made the initiation of such investigations the more opportune. The object aimed at was twofold:

(*a*) To demonstrate the efficiency of pasteurisation as carried out at certain factories.

(*b*) To demonstrate whether or not the product was recontaminated after pasteurisation, and if so, how the infection took place.

The methods followed were very similar in all cases and were carried out as follows:—

1. Samples were taken of the cream on arrival at the factory, after blending in bulk.
2. The same lot of cream, after being neutralised and pasteurised by either the "flash" or the "holding" system as it came from the outlet pipe of the "flash" or (in the case of the holding system) direct from the tank, was again sampled. In both cases these samples were obtained before the cooling process commenced.
3. In the case of the flash pasteurisation, the plates were exposed 2½ minutes, and in one case (Example 1) five minutes to the air over the pipe cooler used first to reduce the temperature of the cream.
4. Plates were atmospherically exposed for fifteen minutes over the cream-receiving and neutralising vat in the case of Example 1 to demonstrate the extent of infection from the water spray tower; in other cases this was not done.
5. Where vats were used for holding cream (after passing over pipe coolers) pending churning, the tops of such vats being open, another series of plates were exposed to the atmosphere—for 2½ minutes in one case (Example 2) and five minutes in another (Example 1).
6. The same cream was again sampled as it came from the holding vats to enter the churns.
7. A sample was taken of the water used for cleansing and rinsing the churns and utensils.
8. A sample was taken of the water used to bring butter to the breaking point and thereafter used to wash the butter.
9. A sample was taken of the butter made from the aforementioned cream as it came from the churn.
10. Plates were generally atmospherically exposed in the churn room 2½ minutes, but in one case (Example 1) for five minutes, in all cases where the butter (or cream as it gravitated along the fluming from vat to churn) was exposed to the air.
11. A sample of the surface of the butter was taken from a box when packed and ready to be lidded.

In conjunction with making these bacteriological examinations, the produce was graded for quality at all stages, thus:—

(*a*) Cream on arrival at factory.

(*b*) Cream after treatment when ready to churn.

(*c*) Butter soon after being manufactured.

Some delay occurred in the earlier stages of the work, but eventually with the co-operation of the Biologist, Dr. G. P. Darnell-Smith, another start was made early in October, 1919, and the results of the first portions of the investigation are now available.

The Dairy and Biological Branches of the Department have approached the work in a spirit of co-operation for the benefit of the dairy industry. The Biological Branch was responsible for the bacteriological results, making the plates, isolating, identifying and counting the various colonies. The Dairy Branch, apart from initiating the scheme, supervised its operations up to the laboratory stage, correlating each step taken so that a comparison of the results might be jointly made and the information applied to the manufacture of dairy produce in a practical manner. Deductions will be made from the data brought to light, and recommendations given as to how the dairy companies can best use them to retain and further enhance the reputation already achieved for the output of their factories.

Example 1.

This factory was built of wood many years ago, renovated to a certain extent about 1910 or 1911, and situated on the bank of a river with a lagoon at the back; the water in the lagoon contained vegetation, was stagnant and heavily charged with germ life. This water was used to pump over the condenser of the refrigerating plant, and gave off a very apparent musty, swampy smell. The surroundings of the factory generally were unsatisfactory, and the inside premises were in a state of disrepair, floors, drains and walls needing attention. Leading from the front verandah (connected with the churn room by large double doors) were two underground earthenware 6-inch drains; these pipes were straight, no bend or sanitary trap being inserted at the factory end. They emptied into a concrete well or sump and carried off all the washings of the churns and factory generally; at the time of our visit a most offensive smell was arising from them and penetrating to all parts of the factory. When the sump was half empty the outlets of the pipes were exposed and a draught of foul air blew right through them into the churn room.

As was to be expected, butter made under such conditions was of inferior quality and showed further rapid deterioration when kept. It was arranged to make an inspection of the premises by bacteriological means, in addition to the outward examination of the premises and surroundings. Samples were taken of the cream, butter and water during the different processes of manufacture, and atmospheric exposures were made as already outlined. A room was given for use as a temporary laboratory, and in five days after our arrival the company's directors and manager were called in and shown the plates. These were explained and the company's representatives then taken through the premises and shown where the infections came from. As far as we know, this is the first time that dairy factory buildings have been scientifically inspected in this manner, and the result has been, from the Department's point of view, satisfactory. There is no disputing the results when obtained

in such a manner—the ocular evidence is irrefutable and the Inspector's position vastly strengthened. Moreover, the directors of a company are able to prove to their shareholders how the deterioration in the quality of their factory's produce and the financial loss thus brought about takes place. Such a loss would be cut out and recovered by the building of a new factory, situated in a more convenient and sanitary position, on up-to-date lines. The cost of building and equipping at the present time may seem hard to bear, but the ultimate cost is less than the loss, year in and year out, of several shillings per cwt. on the selling price of the butter manufactured. Lifting the quality of the butter by a few points means obtaining bigger returns. Take, for instance, a factory with an output of 35 tons of butter per week. If an extra 3s. per cwt. is obtained, it means over £100 per week extra revenue, and it does not take many years at that rate to pay for a modern, well-equipped factory. This lesson has been proved and demonstrated by the Manning River Co-operative Dairy Company. The quality of the butter now put on the market by that company is so improved as to be incomparable with that manufactured under the old conditions. It was proved at the same time that a saving of some £14 per week in labour was effected. In the modern, well-equipped factory nine men, working ordinary time, handled a much greater output than was done under the old conditions with thirteen men, often earning overtime rates of pay.

The manufacture of butter may be described as a fermentative industry, the flavour being due to the absorption by the fat of certain aromatic substances produced during the acid fermentation of the lactose of the milk or cream by *Bacterium lactis acidi* and related organisms. Most of the abnormal flavours are due to the replacement of the desirable acid-forming bacteria with other types of micro-organisms. Hence, to control the flavour of the butter the butter-maker must control the bacteria in the cream that cause the ripening.

As it is freshly drawn from the normal udder of the healthy cow, milk contains bacteria in greater or lesser numbers, the initial contamination taking place in the milk cistern and larger milk ducts of the udder. These organisms appear to cause no change in the market value of the milk, or in the persons drinking the milk. If, however, the cow is suffering from disease in the udder, such as tuberculosis, mammitis or other inflammatory trouble, the milk may contain many millions of the specific bacteria at the time when it is drawn. The extent of all subsequent contamination is dependent upon the manner and care with which the milk is produced and handled. The atmosphere, utensils, milking machines, and the milkers themselves add many bacteria; their future development is largely dependent upon the temperature at which the milk is kept.

Most micro-organisms find in milk an ideal culture medium for their growth. The food elements such as protein and milk sugar, being in liquid form, are most easily attacked, and it is the breaking down of these, by bacterial enzymes formed, which cause most of the undesirable changes

The cream of milk, whether separated by gravity or by means of the separator, will contain considerably more bacteria per unit volume than the milk. The tiny fat globules passing through the milk serum carry mechanically many bacteria of the milk into the cream, which on arrival at the butter factory and often only a few hours old, is in many cases badly contaminated with bacteria. Experience teaches that such contamination can be avoided by efficient pasteurisation (and, if necessary, by neutralisation of excessive acidity) combined with the after-use of a pure culture starter. At the several butter factories visited, all samples were collected with sterile instruments and placed in sterile vessels, and the plating was carried out within half an hour of collecting the samples.

In the case of example No. 1, an upstairs room in the factory was selected as the most suitable of those available, and although the conditions were not comparable with those of the laboratory, every precaution was taken to prevent undue contamination. The poured plates, with suitable dilutions of the various samples, were kept at 30 deg. Cent. for four days, when counting of the bacterial colonies was commenced, and the organisms were isolated in pure culture and classified according to their action on litmus milk, gelatin, glucose and lactose broth. Smear preparations from the different colonies were stained by Gram's method for microscopic examination. The media used for plating were ordinaty agar, glucose agar, litmus lactose agar, an acid agar specially suitable for the development of moulds, yeast, &c. Samples were also inoculated into peptone water containing bile, salt and glucose, for the ready determination of gas formers. All media were prepared at the Biological Laboratory, Sydney, by Mr. W. J. Reay. Assistance was also given by Mr. W. A. Birmingham in determining mould growths.

TABLE I.—Showing Numbers and Kinds of Micro-organisms found in 1 Gram (1 c.c.) of the following samples.

	Total Micro-organisms.	Gelatin Liquefiers and Casein Digesters.	Acid and Acid Coagulating.	Acid and Gas Formers.	Alkaline and Inert.	Yeasts.	Oidium.	Moulds
(H2) Cream before pasteurising	162,749,000	770,000	160,250,000	1,840,000	50,000	3,000	6,000	10,000
(J1) Cream immediately after pasteurising..	24,700	200	24,400	....	100	....	....	....
(K1) Cream twenty hours after pasteurising	1,296,500	543,500	380,000	1,000	367,000	3,000	2,000	
(L) Butter in churn before salting ..	443,900	100,000	310,000	600	32,000	300	1,000	
(M1) Butter in box after packing	2,244,000	724,000	1,330,000	1,000	150,090	10,000	10,000	
(N) Butter-wash water..	329	27	11	....	280	2	....	
(O1) General service water (town supply)	2,409	730	300	5	1,230	44	....	

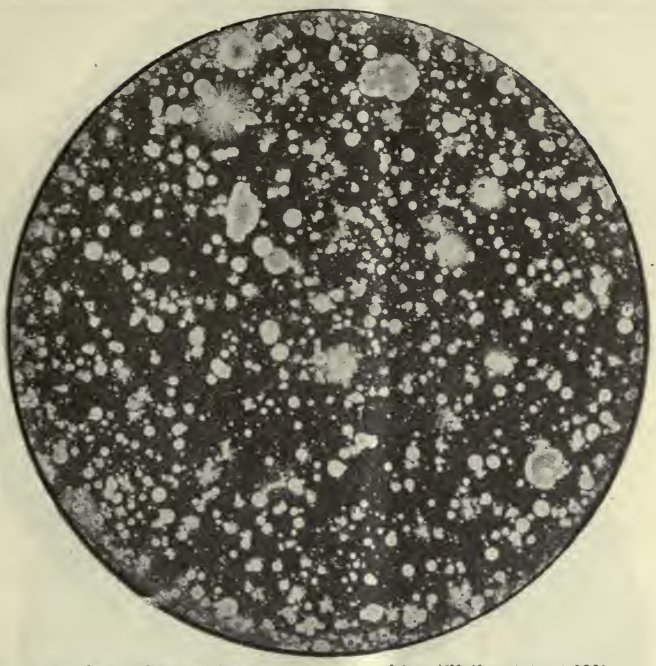
Sample H2—Cream before Pasteurising.—Before pasteurising, and after thorough mixing in the 300-gallon cream-receiving vat, the cream was collected by means of a sterile pipette; it was received at the butter factory in cans from the surrounding dairy farms, and its acidity was determined at

0·6 per cent. of lactic acid. The plates showed the presence of a total of 162,749,000 micro-organisms; of these, 1,840,000 were organisms of the *Bact. Coli* group, or undesirable lactose fermenters, of which three varieties were isolated, viz., *Bact. Coli communis*, *Bact. acidi lactici* and *Bact. lactis ærogenes*. Their presence in cream is evidence also of a proportion of volatile acids (acetic and formic), so the 160,250,000 true lactose fermenters, *Bact. lactis acidi* type, were not entirely responsible for the acidity of the cream. Amongst the 770,000 gelatin liquefiers and casein digesters, were *Bact. prodigious*, a species of the *Proteus* group, and *Sarcina lutea*, a liquefying micrococcus and cladothrix sp.; 19,000 micro-organisms, comprising species of moulds, oidium and yeasts, were counted, while the 50,000 bacteria causing alkalinity or no apparent change in litmus milk were both bacillary and coccal forms.

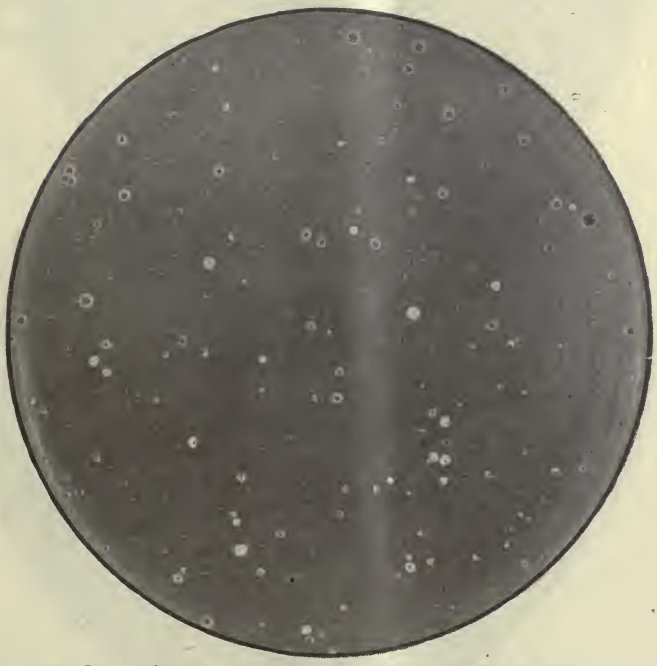
*Sample J*1—*Cream after Pasteurising.*—The cream was collected by means of a sterile pipette immediately after being discharged from the outlet pipe of the pasteuriser at a temperature of 180 deg. Fah. The sample was neutralised to 0·2 per cent acidity with lime, and pasteurised by means of the flash system, then cooled to 54 deg. Fah. by passing over pipe-coolers.

It has been seen from the figures in Table I that 162,749,000 micro-organisms in 1 c.c. of the cream were reduced by pasteurisation to 24,700. Of these there were 200 per c.c. gelatin liquefiers of the *B. Mycoides* type of spore-forming organisms. The remainder, 24,500 per c.c., were insignificant, inasmuch as only slight acidity, without noticeable taste or odour, was produced by them in litmus milk in three weeks.

*Sample K*1—*Cream immediately prior to Churning.*—After being pasteurised and pumped over the pipe-coolers the cream was gravitated into circular holding vats, each about 6 feet in diameter and 4½ feet deep, provided with semi-rotary pipe brine coolers. These vats were placed in a room about 12 feet wide by some 40 feet in length. The walls, which were of fibro-cement, were cracked, and broken, and dirty. The floor, also greasy and dirty, was of hardwood, badly jointed, and in places leaked through to the basement underneath. The beading round the bottom of the walls was loose and rotting, and the room was ill-ventilated and lighted, and generally in a state of disrepair and uncleanliness. The vats had open tops and the contents were exposed to contamination from the above conditions. No "starter" was added to the cream, which, pending churning, was held over-night (twenty hours) at 57 deg. Fah. Here the plates show that 1 c.c. of cream contained 1,291,500 micro-organisms; 180,000 of these were found to be desirable lactose fermenters or organisms of *Bact. lactis acidi* type and 1,000 were acid and gas formers of the coliform group, viz., *Bact. lactis ærogenes*. Amongst the 543,500 gelatin liquefiers and casein digesters were *Bact. proteus mirabilis*, *Bact. fluorescens liquefaciens*, *Sarcina lutea*, and a gram-positive bacterium. The 367,000 producing alkalinity or no change in litmus milk were both rod-shaped and spherical forms, some being



Agar Plate Culture of Cream before pasteurising (dilution 1 to 1,000), showing the extent of infection at the farm dairy.
Total micro-organisms 162,749,000 per c.c. (Original.)



Agar Plate Culture of Cream immediately after pasteurising (dilution 1 to 100), showing beneficial effect of pasteurisation.
Total count shows a reduction of organisms from 162,749,000 to 24,700. (Original.)

Agar Plate Culture of Cream before churning, twenty hours after pasteurising (dilution 1 to 1,000).

Note the enormous increase of undesirable organisms, the result of contamination by factory conditions, which have nullified the benefits of pasteurisation. (Original.)

Agar Plate Culture, obtained from surface of butter in box after packing (dilution 1 to 1,000).

Total count representing 2,244,000 micro-organisms per gram. (Original.)

Plates exposed to atmosphere inside factory for five minutes, showing growth of colonies of moulds, yeasts and bacteria, demonstrating the extent of infection from the interior of an old, badly-planned factory. (Original.)

B—Cream Attemperator Room. Media used, acid agar.
D2—Butter-working and Packing Room Media used, litmus lactose agar.
F—Butter Cold-storeroom, adjoining Butter-working and Packing Room. Media used, ordinary agar

chromogenic. Two thousand colonies, comprising two species of oidium and 3,000 yeasts, were also counted ; 200,000 micrococci were found to produce acid in litmus milk, but failed to coagulate it in ten days.

Sample L—Butter in Churn before Salting.—The cream from the attemperator, or holding vats after cooling to 50 deg. Fah. was churned in a box churn for about thirty-five minutes, and the sample of butter for plating was collected by means of a sterile measure before the addition of salt or preservative. From the plates it was ascertained that one gram of butter contained 443,000 micro-organisms. The majority of these, but considerably reduced in numbers, were similar varieties to those found in sample *K*1. From the figures in Table I it is seen that nearly two-thirds of the total micro-organisms in the cream before churning, were carried away with the buttermilk. The additional organisms appearing on the plates were *Bact. fluorescens non liquefaciens, Bac. fulvum* and a streptococcus, the probable source of all of which was the butter-wash water.

*Sample M*1—*Butter in box after Packing.*—After washing, the butter was removed from the churn to another room to be salted and worked on an ordinary 6-foot diameter butter worker (a circular table on which revolved corrugated or fluted rollers). The churn used, as already stated, was of the wooden box type, and of about 1,000 lb. butter capacity. The butter was handled from churn to barrow, from barrow to worker, and from worker to package by wooden shovels, and was packed into the latter by means of a wooden rammer. This is mentioned in view of these instruments being possible means of contamination. The sample for plating was taken with a sterile measure from (and near the surface of) the butter in the box. From these plates it was shown that one gram of butter contained 2,244,000 micro-organisms. Of these 1,330,000 coagulated milk with production of lactic acid, 1,000,000 were of the *Bact. lactis acidi* type and 10,000 a lactic bacillus of *Bact. bulgaricus* type and may be classed as desirable lactose fermenters, while 320,000 were streptococci, varieties of which are often associated with disease conditions. Amongst the 724,000 gelatin liquefiers and casein digesters, were present *Proteus mirabilis, Bact. fluorescens liquefaciens, Staphlococcus aureus, Micrococcus flavus. Bact. Zopfii,* a variety of proteus which does not liquefy gelatin, was also present. One thousand undesirable lactose fermenters, *Bact. lactis œrogenes,* were found. The 150,000 making litmus milk alkaline were of both spherical and rod forms. The yeasts and oidium lactis numbered 20,000, while the 20,000 mould growths were *Cladosporium herbarum* and two species of *Penicillium.*

Sample N—Butter Wash Water.—The water used for washing the butter was obtained from the ordinary town supply, and was delivered into a large tank where it was subjected to a process of chilling before using. The sample for plating was collected into a sterile vessel from the delivery pipe in the churn room. From the counts it was found that 1 c.c. of water contained 329 micro-organisms ; of these, twenty-seven, comprising *Bact. fluorescens liquefaciens, Bact. mycoides, Micrococcus flavus,* were able to liquefy gelatin and digest the casein of milk. There were five colonies of a micrococcus

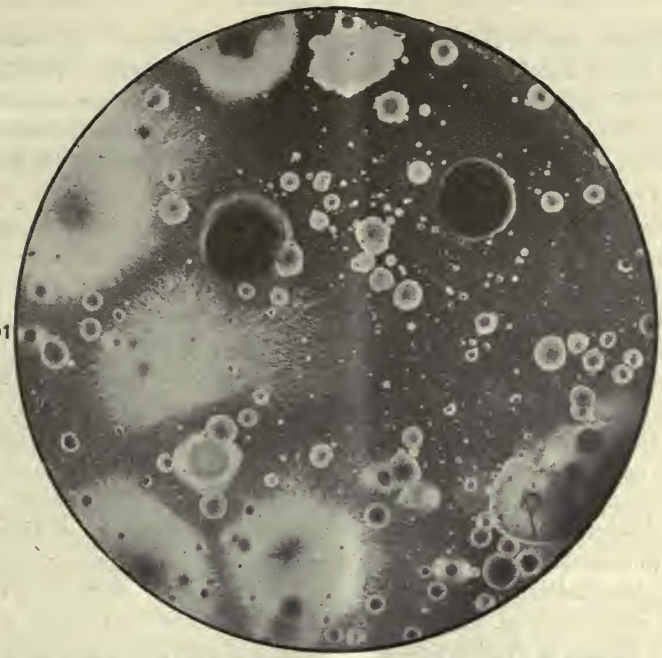


Plate Culture of general service water from town supply used in the factory.
Total micro-organisms per c.c., 2,400. (Original.)

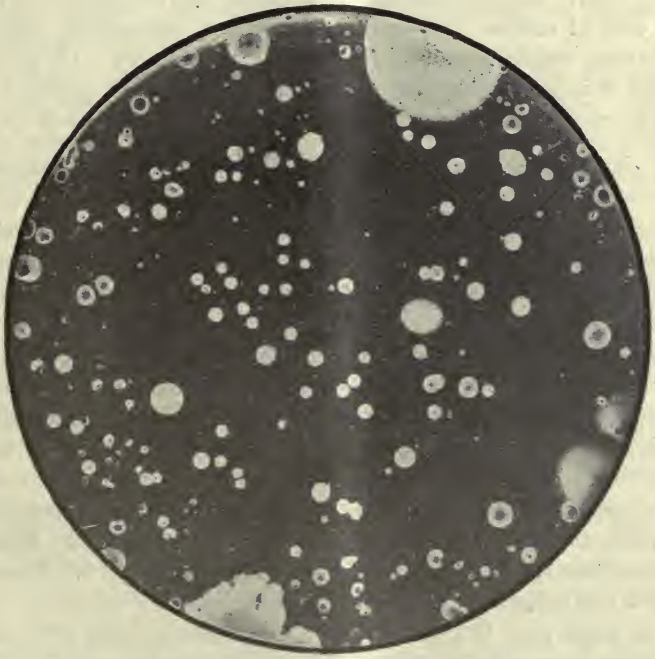


Plate Culture of water used for washing butter. (Town supply, chilled to 40 deg. Fahr.).
Total micro-organisms per c.c 329. (Original.)

which produced acid in litmus milk but failed to coagulate it in three weeks, while six streptococci readily produced both acid and clot. Two hundred and eighty of the total bacteria in the water were inert or caused slight alkalinity when inoculated into litmus milk. There were present two colonies of pink yeast or torula, while the nine mould growths were species of *Cladosporium, Phoma, Penicillium, and Mucor.*

Sample O1—General Service Water.—The source of this water, as in the case of sample *N*, was the head waters of a coastal river. The water was distributed from a conveniently positioned reservoir by means of the ordinary system of mains and smaller pipes. The sample for plating was collected into a sterile vessel from a tap on the cream-receiving platform. From the counts, 1 c.c. of water contained 2,409 micro-organisms. Of these 730 were classified as gelatin liquefiers and casein digesters. They included *Bact. mycoides, Bact. pyocyaneous, Bact. fluorescens liquefaciens, Bact. proteus vulgaris,* and a large celled micrococcus. Of the undesirable lactose fermenters five colonies of *Bact. lactis ærogenes* were counted. There were 300 bacteria producing acid in litmus milk, while 100 of them were also able to coagulate it; 1,230 were determined as inert, causing no change, or only slight alkalinity in litmus milk in three weeks. Forty-four colonies of yeasts were counted, and there were also present 100 mould growths, comprising species of *Penicillium Fusarium, Cladosporium, and Papulospora.*

As noted, both waters were from the same source of supply. The difference in bacterial counts might be accounted for by the fact (*a*) that in still waters as in the case of sample *N* (butter wash water), suspended matter and bacteria having weight naturally gravitate to the bottom; (*b*) that a low temperature is injurious to many kinds of bacteria, even polluted waters showing a marked decrease of intestinal organisms if the sample is kept cold.

Plate (A) Demonstrating Air Infection arising from Spray of Polluted Water.

A.—Poured plates of ordinary agar, litmus lactose agar and acid agar were placed on the edge of the cream-receiving vat; the lids were removed for fifteen minutes. After four days incubation, counting of the colonies was commenced.

The total bacterial colonies appearing on the agar plate was 4,800. Pure cultures were made of *Proteus mirabilis, Bact. fluorescens liquefaciens, Bact. lactis ærogenes, Oidium lactis, Bact. aurantiacus,* and several chromogenic micrococci. The colonies were too thick to enable the numbers of varieties to be counted.

The acid agar plate showed a total of 161 micro-organisms; fifty-four were mould growths as follows: Cladosporium sp. 29; Fusarium sp. 8; Aspergillus sp. 2; Penicillium sp. 8; Epicoccum sp. 4; Alternaria sp. 3. There were also counted 102 colonies of yeast and 5 *B. subtilis.*

It will be noted that in this case the cream-receiving vats were adjacent to the condenser tower (about 25 feet distant), the water flowing over which was pumped from a shallow stagnant lagoon adjacent to the factory

premises. A favourable breeze would carry a fine spray of this polluted water through the factory. Then, since the diameter of the culture plate is 3½ inches, into which at least 4,961 micro-organisms had fallen in fifteen minutes, some idea might be gained as to the extent to which cream and butter is subject to contamination with undesirable organisms from such a source.

PLATES (B, C, D, E, AND F) EXPOSED TO ATMOSPHERE TO SHOW EXTENT OF MOULD INFECTION WITHIN THE FACTORY.

B.—An acid agar plate exposed to the atmosphere in the cream attemperator room for five minutes, and after incubation for four days, developed a total of thirty-six colonies of micro-organisms. Of these, twelve were yeasts, three *Micrococcus rosens* T., one colony was of a sporing bacillus, while the twenty mould growths were as follows:—Cladosporium sp. 9; Aspergillus sp. 2; Fusarius sp. 1; Spicaria sp. 6; Cephalosporium sp. 2.

C.—An acid agar plate exposed to the atmosphere in the churning room for five minutes developed thirty-nine mould growths and four colonies of yeast. Following are the moulds:—Cladosporium sp. 23; Penicillium sp. 12; Epicoccum sp. 2; Aspergillus sp. 2.

D.—Ordinary agar plate exposed to the atmosphere in the butter-working room for five minutes developed a total of thirty-two colonies of micro-organisms. Seven of these were mould growths comprising species of Cladosporium and Epicoccum. Eleven were yeasts, while the fourteen bacterial colonies were *Sarcina aurentiaca, Micrococcus rosens*, a sporing bacillus and Cladothrix sp.

E.—Glucose agar plate exposed for five minutes to the atmosphere in the storeroom for empty boxes, butter-paper, salt, &c. The total count of micro-organisms was thirty-four. Twenty-one of these were mould growths comprising species of: Cladosporium, Alternaria, Penicillium and Epicoccum. Three colonies of yeast were counted, while amongst the bacterial colonies were *Staphlococcus albus*, Sarcina and Cladothrix sp.

F.—Ordinary agar plate exposed five minutes to the atmosphere in the cold room. The total count of micro-organisms was forty-eight. Thirty-eight of these were mould growths comprising species of Penicillium, Alternaria and Cladosporium. Two colonies of yeast appeared, one Cladothrix sp., three *Bact. subtilis*, and three yellowish slimy colonies of a gram-positive bacterium which rapidly liquefies gelatin.

Summary of Results.—The large numbers of undesirable organisms found in the cream before pasteurising suggests unsatisfactory and unclean conditions on at least some of the dairy farms. Pasteurisation effectively destroyed all vegetative forms of undesirable organisms. The holding of the pasteurised cream in open vats, exposed to the air and dust of an old factory with insanitary surroundings is disastrous, seeing that from the plates over half a million per c.c. of undesirable organisms were added in twenty hours. These would be sure to exert their deteriorating influence upon the good-keeping qualities of the butter.

The system of working and salting butter on an open worker facilitates the inclusion of many bacteria, moulds, oidium, and yeasts.

The plates, poured with the waters used at the factory, suggests that bacteria are reduced in numbers by chilling to 40 deg. Fah. The atmospheric exposure plates indicate plainly the amount of re-contamination that took place from exposure of the cream and butter to the conditions and surroundings of these old and (in a hygienic sense) badly constructed rooms. They also point to the advisability of doing away with all overhead obstructions (beams, pipes, belting, flat ceilings, &c.) that collect or distribute dust.

The presence of such large numbers of undesirable water bacteria as those shown in the plate exposed over the cream-receiving vat (adjacent to the water-spray tower), and in subsequent plates of cream and butter, indicates the danger incurred in exposing cream and butter to outside influences—in this case arising from the infection constantly being carried into the factory by the spray of the condenser water tower, the source of supply for which came from the stagnant lagoons described above. The necessity of draining all such stagnant pools and lagoons cannot be too strongly emphasised.

Example 2.

It had been noted that the choicest quality butter manufactured in a certain large factory, while true to description as regards quality immediately after manufacture, soon began to show signs of deterioration, and when kept in cold storage for any lengthy period became unmistakably "off" in flavour and aroma.

As a result of the series of examinations made at different stages of the manufacture, it was ascertained that while the pasteurising of the cream was effectively done, in that the bacteria were practically all killed, yet this same pasteurised cream, on being put into the churn, was found to be contaminated in the same manner as when first received at the factory. On inquiry it was found that the manager, following out advice he had received, was using a quantity of high acid unpasteurised cream as a "starter" for that which had been neutralised and pasteurised. The "starter" cream was found to contain similar germs to those in the bulk of the supply, and as a consequence the work and expense of pasteurising were being nullified. On the plates being shown and the matter explained, the factory manager at once discontinued the practice.

Selecting special cans of cream from the general supply to be used as "starters" in this way is a very dangerous procedure; even with the most skilled operator mistakes must occur, and it should be discontinued wherever it has been in vogue. In propagating and using "starters" there is no room for guess-work.

This factory, as in the previous example, is an old one erected some twenty years ago, but in a better state of repair and kept in a much more sanitary condition. The design is similar, and likewise there are a number of rooms on the first storey. The main walls and partitions, as also the ceilings and

the upper floor, are of wood. The walls and ceilings right throughout the factory had been whitewashed with freshly-slaked hot lime a few days previous to our inspection. This fact had a great bearing on the small counts found in the atmospherically exposed plates, as the application of the hot lime would have the effect of destroying many organisms—especially mould growths—for the cultivation of which the medias used were specially selected.

The cream treated at the factory was in all cases delivered by road vehicles—in a few by carriers plying for hire, but mostly by the dairy-farmers themselves. In transit from farm to factory it was held in 6 or 8 gallon cans, mostly of tinned steel and in good condition. The bulk of the supply was received before midday. On arrival each can was weighed, sampled for testing, and graded for quality. The cream receiving platform was open to the yard, and there was no partition between it and the receiving vats, pasteuriser, and pipe-cooler. After passing over the ground-floor cooler the cream was pumped up to another cooler on the next floor, immediately overhead, and from there taken in an open fluming to the holding vats, which were fitted with coils in order to regulate the temperature and bring it down as required for churning. This is necessary in the summer time, as the cream remains in these vats overnight, being churned the following morning.

The upstairs cooler was placed in a small gable-end room with low ceiling, through which was an air shaft; further ventilation was provided through a glass window, which was kept open, and through which a good breeze was blowing at the time the plates were exposed. The attemperator vats were placed in an adjoining room of much larger size, but also with low ceiling These vats were immediately over the churns.

The cream examined was received in good condition and was closely graded by the Department's officers, and found to be of choicest quality. It will be seen from the plate B1 that much latent infection was present. The great number of organisms of the coli group demonstrate contamination at the cow-yard and bails; other types present indicate that the cows had in some cases access to swampy ground and pools of stagnant water. In B2 it is shown that heating to 182 degrees Fah. practically sterilised the cream and made it possible to manufacture from it a high-grade, good keeping butter, thus proving that extreme care had been exercised in efficiently carrying out pasteurisation. Untreated in this way, such cream would make a butter that would deteriorate to a very low quality within a week.

This care, with all the work and expense attached to it, was largely taken in vain, because of the practice (already referred to) of adding unpasteurised cream as a "starter" (see B3), the sharp acid flavour of which covered up similar latent pollution to that previously destroyed in the bulk of the cream by the pasteurising process. This infection was found in the butter when marketed, and was mainly responsible for reducing its grade, when made, from 43 points for flavour (choicest quality) to 38 points (or second grade and unfit for table use), some six weeks afterwards. In the interval this butter was kept in cold storage at 10 degrees Fah.

It will be seen from plate B5 that the water used for washing the butter contained liquefiers, gas formers and moulds. This water could be made much better by being thoroughly filtered—for example, through cotton wool or felt pads. Filtering is especially necessary where, as in the present case, the watercourse is accessible to stock which wade in it when drinking, and open for surface infections lying about the surrounding watershed to be washed into it by rains.

TABLE II.—Showing Numbers and Kinds of Micro-organisms found in 1 Gram (1 c.c.) of the following samples.

	Total Micro-organisms.	Gelatin Liquefiers and Casein Digesters.	Acid and Acid Coagulating.	Acid and Gas Formers.	Alkaline and Inert.	Yeasts.	Moulds.
(B1) Cream before pasteurising..	108,355,000	30,000	107,000,000	1,312,000	6,000	5,000	2,000
(B2) Cream immediately after pasteurising	14,480	....	14,480	....	....	....	....
(B3) Cream 20 hours after pasteurising and immediately before churning	20,448,000	120,000	20,000,000	116,000	200,000	10,000	2,000
(B4) Butter in box after packing	4,246,100	33,100	4,200,000	1,000	3,000	7,000	2,000
B5) Butter-wash water	22,800	8,800	5,200	6,400	1,400	....	1,000
	No oidiums were present.						

Sample B1—Cream before Pasteurising.—The sample for plating was collected from the bulk in the cream-receiving vat by means of a sterile pipette. Each can of this cream had been graded choicest quality, then thoroughly mixed in the cream-receiving vat of 300 gallons capacity. The acidity was determined at 0·44 per cent. lactic acid. From the plates it is shown that 1 c.c. of cream contained 108,355,000 micro-organisms, in which *Bact. lactis acidi* a desirable type, was the predominant organism. There were also present 30,000 peptonising bacteria including varieties of micrococci, sarcina, cladathrix and *Bact. fluorescens liquefaciens*, and 1,312,000 organisms of the coli group or undesirable lactose fermenters. Their presence in such large numbers is undoubted evidence of heavy pollution by fæcal contamination. Among the acid and acid coagulating bacteria were 7,000,000 streptococci, the cells being oval and in long chains. Although these organisms coagulate milk, on account of their resemblance to a pathogenic variety they are regarded as undesirable. There were 6,000 chromogenic micrococci which made litmus milk alkaline but were unable to liquefy gelatin ; these may be classed as inert. Some 5,000 colonies of yeast were counted, while the 2,000 mould growths were *Penicillium* sp.

Sample B2—Cream immediately after Pasteurising.—The sample for plating was collected by means of a sterile pipette immediately after being discharged from the outlet pipe of the pasteuriser. The cream had been neutralised to 0·24 per cent. acidity with lime and pasteurised by means of the flash system, where a temperature of 182 degrees Fah. was reached for a few seconds ; then cooled to 54 degrees Fah. by passing over pipe-coolers. It will be seen from the figures in Table II that 108,355,000 micro-organism

in 1 c.c. of the cream were reduced by pasteurisation to 14,480; of these none were able to liquefy gelatin. Litmus milk was slowly made acid and eventually coagulated. The organisms were all rod forms, growth on all media being slow; stained preparations from old cultures showed metachromatic granules, but spores were not found.

Sample B3—Cream immediately prior to Churning.—The cream after being pasteurised and pumped over the pipe-coolers was run into attemperator or holding vats, where it was left overnight at 57 degrees Fah. Selected cans of cream were added as "starter." These cans were chosen on account of the clean acid flavour of the cream. While this desired acid flavour would be caused by *Bact. lactis acidi*, a harmless and necessary type, it is evident that the conditions which allowed the entry and development of this desirable organism would also be favourable for the entry into the milk and cream of many undesirable types. The plates clearly indicate this, as it was ascertained that 1 c.c. of the cream contained 20,448,000 micro-organisms. Although 20,000,000 of these were "lactics," or desirable lactose fermenters, there were also 448,000 per c.c. of undesirable organisms, comprising 116,000 undesirable lactose fermenters or organisms of the coli group, 100,000 of the proteus group (a putrefactive type), 20,000 *Sareina lutea*, 10,000 yeasts, and 2,000 moulds. There were also counted 200,000 bacteria, which were unable to liquefy gelatin, and which, when inoculated into litmus milk, caused alkalinity or no apparent change in ten days; these were both spherical and rod forms.

Sample B4.—Butter in the Box after Packing.—The cream from the attemperator or holding vats was gravitated over pipe-coolers and churned in a combination "Simplex" churn at 51 degrees Fah. The sample for plating was taken from the near surface butter as packed in the box, by means of a sterile measure. From the plates it was shown that one gram of butter contained 4,246,100 micro-organisms. They included many of the types found in the cream prior to churning, the numbers, however, being considerably reduced, many having been carried away with the buttermilk and wash waters, as a comparison with the butter-wash water will show. Of the total bacterial content 4,000,000 were "lactics," or desirable lactose fermenters; 200,000 micrococci produced acid in litmus milk, but failed to coagulate it in ten days. The 33,100 gelatin liquefiers included *Bact. fluorescens liquefaciens*, *Staphlococcus aureus*, *Sarcina lutea*, *Bact. proteus*, and *Bact. lactis aerogenes*; 3,000 bacteria were considered inert, being unable to liquefy gelatin or cause only alkalinity when inoculated into litmus milk, 7,000 were yeasts, and the 2,000 mould growths were species of *Fusarium* and *Penicillium*.

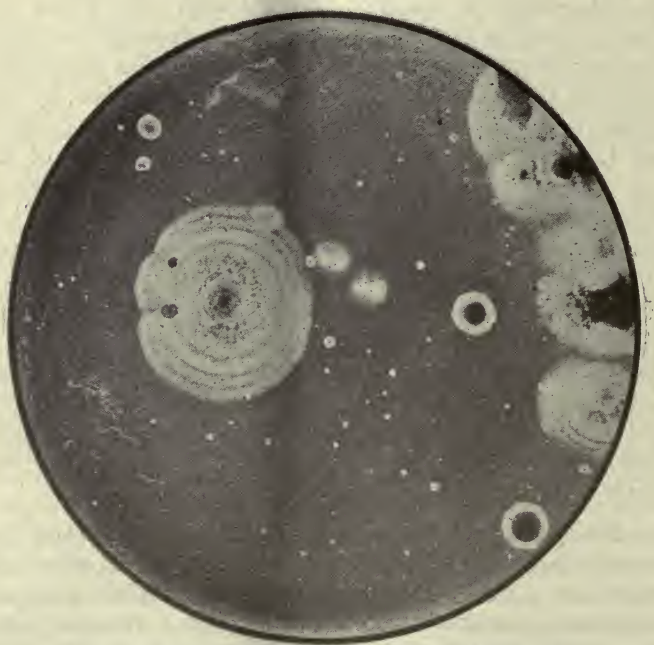
Sample B5—Butter-wash Water.—The water used for washing the butter was obtained direct from a shallow river, which flowed about 100 yards from the factory. This water was drawn through a pipe by the aid of the factory machinery, and delivered into holding tanks. The sample for plating was collected into a sterile tube direct from the tap in the churn room.

B1

Glucose Agar Plate Culture of Cream before pasteurising (dilution, 1 to 1,000).

Note great latent infection. The colonies developed represent 108,355,000 micro-organisms per c.c., largely coliform types. (Original.)

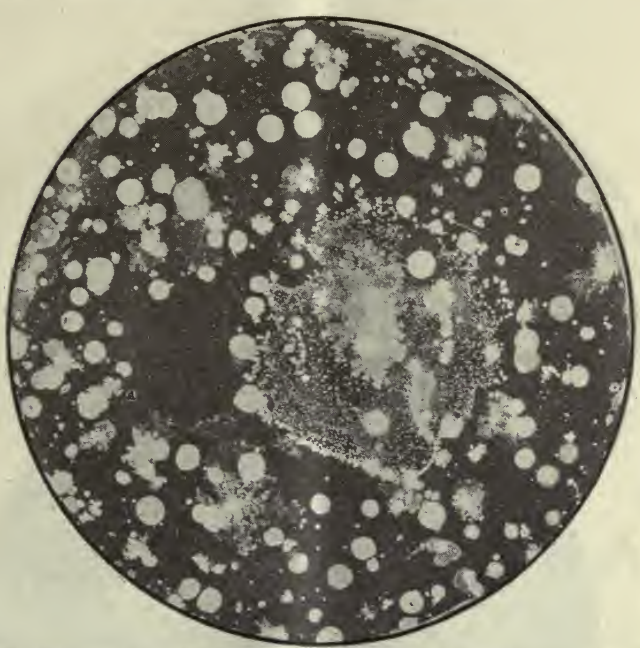
B2



Agar Plate Culture of Cream after pasteurising by flash system, at 182 deg. Fah. (dilution, 1 to 100.)

Note the effect of pasteurisation. Number of organisms reduced from 108,355,000 micro-organisms to 14,480. (Original.)

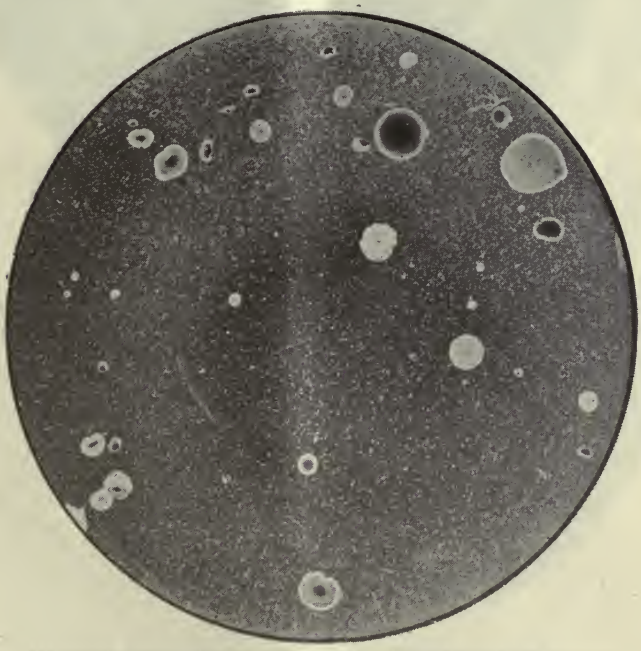
B 3



Agar Plate Culture of Cream immediately before churning (dilution, 1 to 1,000). Held in vats overnight at 57 deg. Fah.

Note the great amount of re-infection that has taken place, largely through a selected unpasteurised can of cream being used as a starter. (Original.)

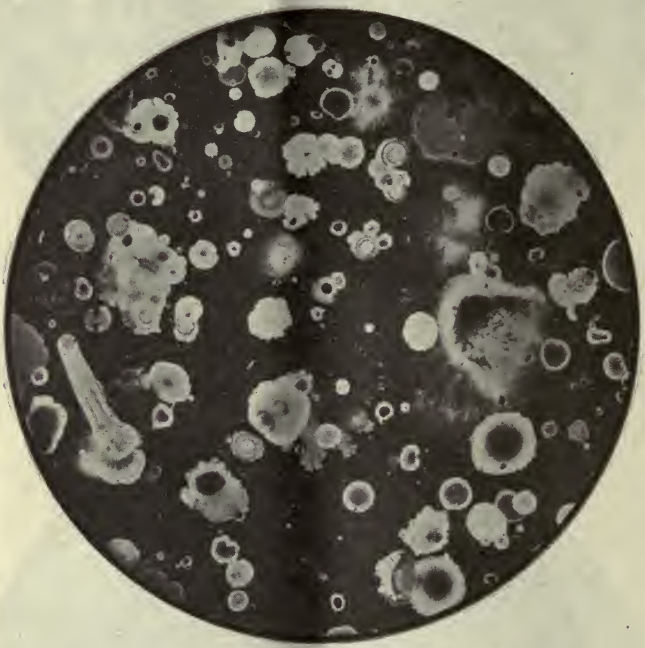
B4



Agar Plate Culture of butter from surface of box after packing (dilution, 1 to 1,000).

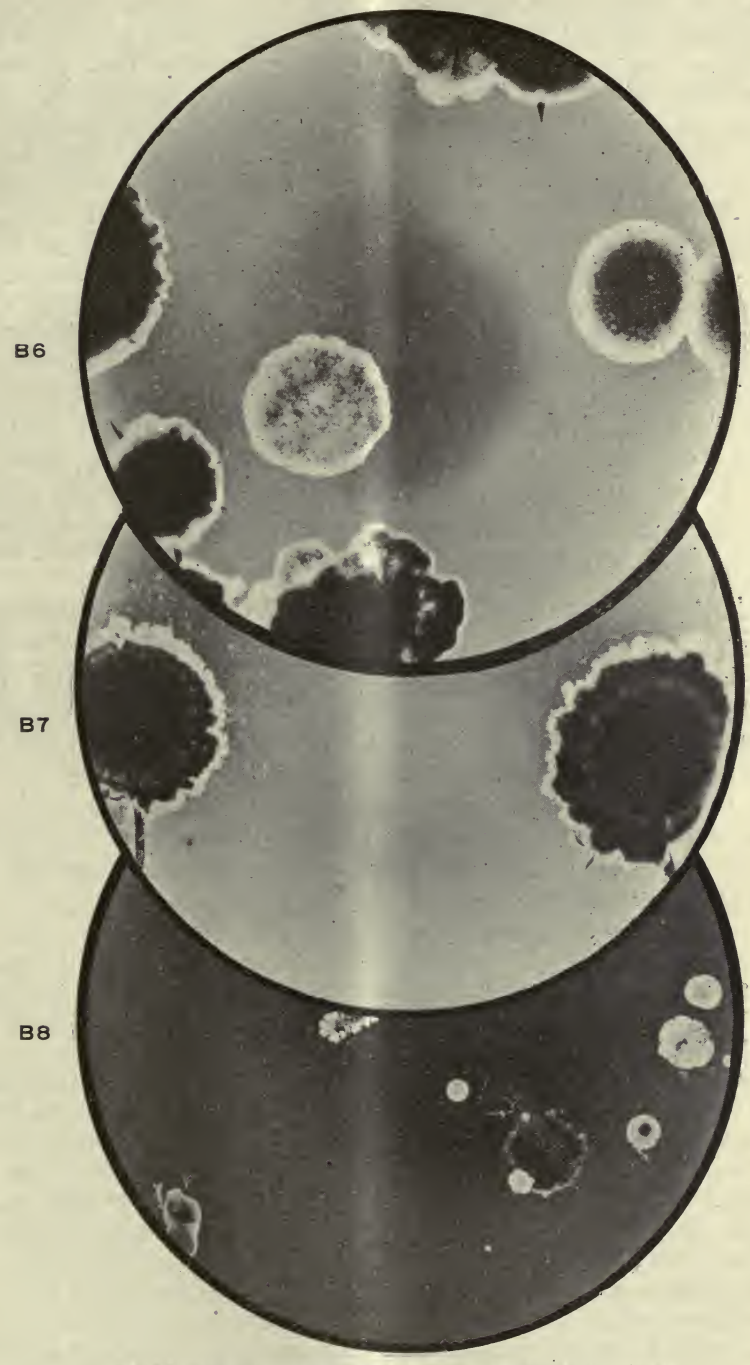
Note many of the organisms shown in B3 have been eliminated through draining off the buttermilk and wash waters. (Original.)

B5



Agar Plate Culture of water used for washing butter, pumped direct from river (dilution, 1 to 1,000.)

Note the enormous number of moulds, bacteria, &c. (Original.)



Plates exposed to atmosphere inside factory for two and a-half minutes, showing growth of colonies of moulds and bacteria.

B6—Acid Agar Plate—Cream Attemperator Room.
B7—Acid Agar Plate—Churning Room.
B8—Ordinary Agar Plate—Cold Room at chilling temperature. (Original.)

From the plates it was found that 1 c.c. of water contained 22,800 micro-organisms; 8,800 of these were proteolytic types, being able to liquefy gelatin or digest the casein of milk. They included *Bact. fluorescens liquefaciens*, *Micrococcus flavus*, *Staphlococcus aureus*, *Bact. cloacæ*, a gram positive bacillus and a sporing bacillus. The most conclusive proof that the water was heavily contaminated with the organisms of fæcal origin was the presence of 6,400 per c.c. of *Bact. coli*. Three varieties were recognised, viz., *Bact. coli communis*, *Bact. lactis ærogenes*, and *Bact. cloacæ*, all of which can cause gassy fermentation of lactose, while *Bact. cloacæ* is also able to liquefy gelatin. There were 5,200 acid and acid-coagulating organisms, including 2,000 streptococci and 3,200 micrococci, while 1,400 other bacteria caused alkalinity or no apparent change. The 1,000 moulds were species of *Aspergillus*, *Fusarium*, and *Mucor*.

Atmospherically Exposed Plates.—Sterile media in the form of a jelly were melted, and carefully poured into sterile petri dishes, and allowed to solidify. These dishes were carried to the respective rooms of the factory, where the lids were carefully removed, and the media exposed for 2½ minutes to allow the free access of micro-organisms. The media used were ordinary agar, litmus lactose agar, and an acid agar specially suitable for the development of moulds.

*Plate B*6.—An acid agar plate was exposed 2½ minutes to the atmosphere of the cream attemperator room; it showed the development of nine mould growths, including species of *Penicillium*, *Alternaria* and *Aspergillus*.

*Plate B*7.—An acid agar plate exposed 2½ minutes to the atmosphere in the churning room showed the development of two colonies of *Penicillium* sp.

*Plate B*3.—An ordinary agar plate was exposed 2½ minutes to the atmosphere in the cold store room. The total micro-organisms developed were twenty-one; of these, one colony was the mould *Cladosporium* sp., while the remainder were chromogenic bacteria.

Example No. 3.

The best butter of this factory, after being kept for any length of time in cold storage, showed evident signs of deterioration, although up to a week or two after being manufactured it was of choicest quality.

Our investigation showed that the cream as churned was of choicest grade and had been well pasteurised. The infection that was in the cream before being heated, although large, had not had time to develop sufficiently to affect the flavour. This latent contamination was practically wiped out by the system of pasteurisation employed, as was shown by the reduction of the number of colonies in 1 c.c. of cream from 150,997,000 before pasteurising to only 500 after the heating process had been completed. After being held for nineteen hours these increased to 13,400, a striking contrast to what was experienced where a similar comparison was made in the investigations described in Examples Nos. 1 and 2. The increases in the present case were mainly due to normal increase and the multiplication of the spore-formers

undestroyed in pasteurising. The small increase in the number of colonies after nineteen hours' retention of the cream in the closed-in batch-holder demonstrates the advantages of this system of pasteurisation, as far as reinfection from atmosphere and other outside influences is concerned. The cream after being heated is not exposed again, except when in the fluming while gravitating into the churn. This is an important consideration, especially where factories are situated near dusty thoroughfares.

The air exposures made in the churn room show that there was little infection present in the atmosphere. This was to be expected, as the factory in question is situated on the highlands of the Dividing Range.

Air Exposures.—Each dish was carefully exposed for two and a half or three minutes, being carried about the room so that the plate was exposed in every part. The cold room, as is usually the case, showed the presence of moulds in some numbers; spraying or fumigating with formalin would be of benefit. Factory managers cannot keep too strict a watch on these rooms—mould is so easily carried into them by the butter boxes, the timber of which is often infected before it arrives at the factory.

It would be expected that butter made under such conditions would show a small count on being plated. The contrary, however, was experienced. An enormous increase took place (principally organisms of the coli and proteus groups), demonstrating that contamination had been effected somewhere—more than probably through decaying flesh and manure. An examination of the water showed that it was the means by which this infection was carried into the butter. The puzzling part was how to account for the types of bacteria encountered being found in a well 30 feet deep, into which the inflow of water was from the bottom. It was ascertained that drainage conditions were satisfactory, and there was no undesirable soakage of any kind. The tanks containing the water used for butter-washing purposes were too well closed in for infection to enter through them. It was ascertained on inquiry that, beside being used for washing butter, the well was drawn upon for the condenser of the refrigerator, and as this water was considerably raised in temperature in the operation, it was pumped up into a tower, some 20 or 30 feet high, and sprayed to the ground level, where it was caught in a shallow concrete tray and from there gravitated back into the well again. It was further brought to light that the overhead tanks used for holding water for the condensers were exposed to the air, and the bodies of drowned birds were at times found in them. Some distance from the factory, too, there was a pig-run. This was kept exceptionally clean, as pig-runs go, no offensive smells being apparent, but where there are animals there is bound to be excreta, and the opinion is held that it was from this source that the coli type of infection came, the germs adhering to the dust and small particles of dried manure, and being carried by the wind into the tower from which the water was sprayed; entrance could easily be gained through the louvres which formed its sides. Moreover, if any pieces of flesh fed to the pigs were not all devoured, any germs produced could be carried into the water in the same way.

The process of contaminating this water had been going on in this manner for years, until the well had become thoroughly infected.

The manager of the factory was instructed to get a better water supply for use in manufacturing butter, and was strongly recommended to sink another well some distance from the old one and to use the new supply solely for washing butter. The old well could then be set apart for the condensers, boiler, &c. This course was recommended in preference to trying to clean out the well by pumping, it being considered that the walls of the shaft would also be contaminated. It might be noted that the engine and boiler rooms of this factory formed a barrier between the pig-run and the butter and cream compartments; also, on the days our examination was made the weather was calm, which accounts, in part, for the fact that the atmosphere exposures made in the churn room were so clean.

This example serves to emphasise how easily such a perishable product as butter can be contaminated, and how infection can be obtained through most unlooked-for agencies. Who would have suspected that water drawn from a deep underground spring would be steeped in germs that are to be found on the surface? Here again, the care and expense entailed in properly pasteurising cream were incurred only to be partially nullified by reinfecting the butter with the water used for washing it. Water used for such purposes cannot be too closely examined. During the past few months the Dairy Branch has warned several factories on this matter, as a result of bacteriological examinations carried out by the Department. The last instance is one where the water for washing the butter is drawn from a well into which water soaks from an old swamp. The company has put down shafts in different directions with the same result, and as good water is seemingly unobtainable in the vicinity of the present site, the removal of the factory to where it can be got is now under consideration. A pure water supply is an absolute essential for dairy produce factories. Those factories that have one should carefully guard it from contamination. In many cases inferior water can be greatly improved by a proper system of filtering, and even where the supply is fairly good it would be all the better for being filtered—the pipes through which it is pumped in the course of time always become, to a certain extent, dirty and this sedimentary matter should be removed.

TABLE III.—Showing Numbers and Kinds of Micro-organisms found in 1 Gram. (1 c.c.) of the following samples.

Samples.	Total Micro-organisms.	Gelatin Liquefiers and Casein Digesters.	Acid and Acid Coagulating.	Acid and Gas Formers.	Alkaline and Inert.	Yeasts.	Oidium.	Moulds.
(C1) Cream before pasteurising.	150,997,000	498,000	150,200,000	248,000	45,000	3,000	2,000	1,000
(C2) Cream immediately after pasteurising.	500	10	490	....	....	....	....	....
(C3) Cream immediately prior to churning.	13,400	7,500	5,700	....	200	....	....	....
(C4) Butter in box after packing.	750,000	90,000	614,000	4,000	35,000	5,000	....	2,000
(C5) Butter-wash water	11,630	4,160	1,500	3,500	1,500	760	10	200

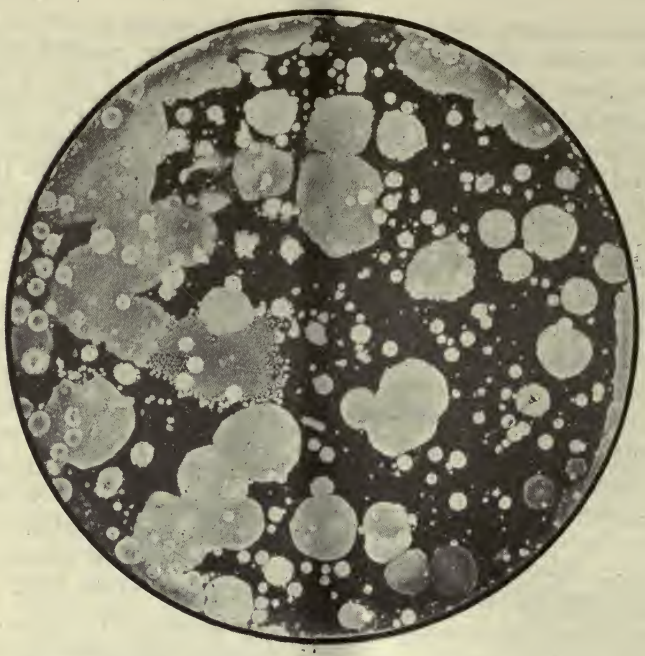
Sample C1—Cream before Pasteurising.—The cream, as received in cans from the various suppliers of the factory, after being weighed and sampled for testing, was graded, and the best quality pumped into a 600-gallon pasteurising holder of the batch type. The acidity of the bulk cream, after this had been well mixed by the rotating coils of the pasteuriser, was determined at 0·48 per cent. lactic acid. A neutralising agent (lime) was added in order to reduce this acidity to the requisite percentage before pasteurisation was carried out. The sample for plating was collected from the bulk cream by means of a sterile pipette in the holding vat, after blending was completed and before the lime had been added. From the plates it was evident 1 c.c. of the cream contained 150,997,000 micro-organisms; of these, 150,000,000 were *Bact. lactis acidi*, or desirable lactic fermenters, and 200,000 were streptococci. Of the total count, 498,000 bacteria (including organisms such as *Proteus vulgaris*, *B. subtilis*, *Bact. fluorescens liquefaciens*, *Bact. fulvum*, and a micrococcus) were able to liquefy gelatin or digest casein of milk; 248,000 were organisms of the coliform group, or undesirable lactose fermenters, while of the 45,000 bacteria which cause alkalinity in litmus milk, *Bact. alcaligenes* was most numerous. Others, both spherical and rod forms, were considered inert, causing no apparent change in litmus milk or gelatin in ten days.

Sample C2—Cream immediately after Pasteurising.—The cream had been neutralised to 0·25 per cent. acidity with lime and pasteurised by means of the holding system, where the cream was raised to 145 deg. Fah., and held at that temperature for twenty minutes. The sample for plating was collected by means of a sterile pipette direct from the vat before the cooling process began. From the plates, 1 c.c. of the cream contained 500 bacteria; of these 490 were gram positive bacteria, which slowly coagulated litmus milk with production of acid, and ten of a sporing bacillus of the *B. subtilis* type.

Sample C3—Cream immediately prior to Churning.—The pasteurised cream was cooled to 55 deg. Fah., and allowed to remain in the pasteurising vat twenty hours (overnight). The lid of the vat was kept closed, and no "starter" was added. The sample for plating was collected by means of a sterile pipette direct from the bulk in the vat. From the plates, 1 c.c. of cream contained 13,400 bacteria. Of these, 1,900 were *Bact. lactis acidi*, or desirable lactose fermenters, 3,800 were streptococci, and 7,500 (including spore-forming organisms of the *B. subtilis* type, *Sarcinæ* and *Cladothrix* sp.) were able to liquefy gelatin. One hundred and fifty were bacteria able to produce alkalinity in milk, and fifty were chromogenic micrococci, classified as inert, having caused no apparent change in litmus milk or gelatin in ten days.

Sample C4—Butter in the Box after Packing.—The cream from the pasteurising and holding vat was gravitated along a fluming into the churn in another room in the factory. The cream was churned in the Simplex churn. The sample for plating was collected by means of a sterile instrument from the near surface butter as packed in the box ready for market. From the plates 1 gram of butter contained 750,000 micro-organisms. Of these, 90,000

C1



Agar Plate Culture of Cream before pasteurising (dilution 1 to 1,000).
Note the amount of latent infection in this cream as delivered at the factory; largely coliform types. (Original.)

C2

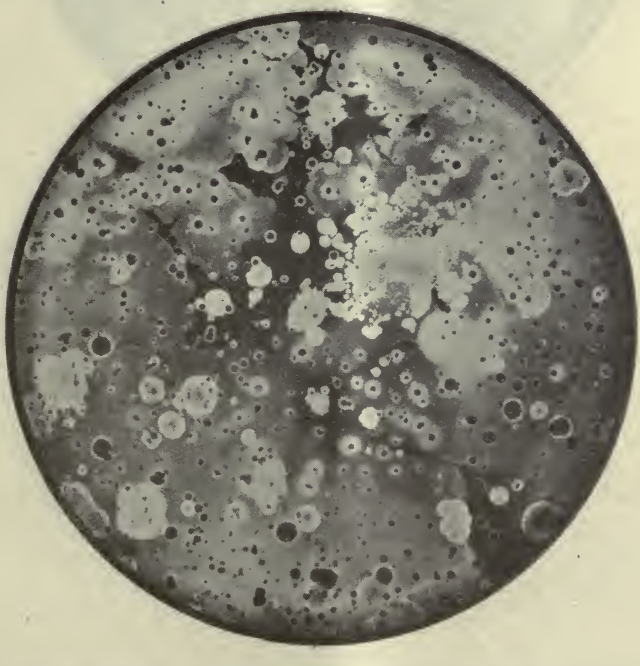
Agar Plate Culture of Cream after pasteurising by holding system, at 145 deg. Fah. (dilution 1 to 10).
Note the great reduction in the count, from 150,997,000 micro-organisms to only 500 per c.c. The latent infection has been killed out before the development could affect the flavour of the cream or butter. (Original.)

C3

Agar Plate Culture of Cream before churning, 19 hours after pasteurising, having been held at 55 deg. Fah. (dilution 1 to 100).

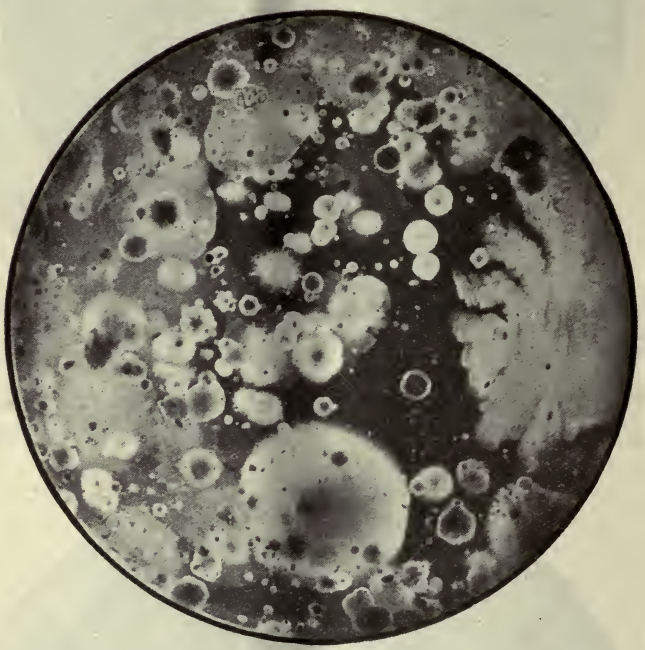
Note that there has been no reinfection from outside influences, such as the air, &c., but the count has increased to 13,400 per c.c. by multiplication of bacteria—lactics and spore-formers—which survived pasteurisation. (Original.)

C4



Litmus Lactose Plate Culture from surface of butter packed ready for market (dilution 1 to 1,000).

Note the enormous reinfection by coli and proteus organisms. Total count, 750,000 per c.c. (Original.)



Litmus Lactose Agar Plate, 1 c.c. of well water used for washing butter.

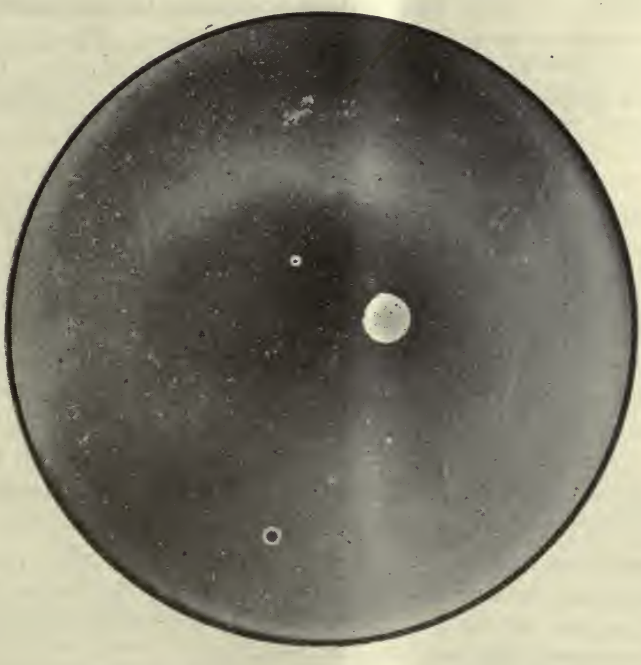
Note the large number of colonies, coli, proteus, and moulds, corresponding with infection found in butter. Total count 11,630 per c.c. (Original.)

C6

Agar Plate of air exposure for 2½ minutes in the cold room at chilling temperature.

Note the slight infection by moulds, &c. (Original.)

C7



Agar Plate of air exposure for 2½ minutes in the churn room.

Note the purity of the air, the locality being an elevated one. (Original.)

(including varieties of the proteus group, *Bact. fluorescens*, spore-forming organisms, *Sarcinæ* and *Bact. prodigiosus*) were gelatin liquefiers, or were able to digest the casein of milk, and 614,000 were bacteria which, when inoculated into litmus milk, produced acid or caused an acid coagulum. Of these lactose fermenters, 500,000 were *Bact. lactis acidi*; 60,000 were streptococci, while the remainder of this type were varieties of micrococci, some being chromogenic. Of the 4,000 organisms of the coliform group, two members were isolated, viz., *Bact. coli communis* and *Bact. lactis aerogenes*. Of the remainder, 25,000 were bacteria able to cause milk to become alkaline; 10,000 were considered as inert, having made no apparent change in gelatin or litmus milk after ten days; 5,000 were yeasts, and the 2,000 moulds were species of *Penicillium, Fusarium*, and *Cladosporium*.

Sample C5—Butter-wash Water.—The source of this supply was a well about 30 feet deep. This same water was also used to flow over the condenser tower and was then allowed to flow back into the well. Samples for plating were collected into sterile vessels from the tap in the churn room and also direct from the well.

The total micro-organisms in 1 c.c. was 11,630. Of these 4,160 were able to liquefy gelatin. They included varieties of the proteus group, *Bact. fulvum* and *Sarcinae, Bact. fluorescens, Bact. prodigiosus*, and several varieties of spore-forming organisms. (Anaerobic spore forms were detected in dilutions of 1 to 100.) Of bacteria able to cause an acid coagulum when inoculated into milk, 1,500 were detected. These included a streptococcus and chromogenic micrococci. Undesirable lactose fermenters numbered 3,500. Of the remaining bacteria, 500 were classified as inert, while 1,000 were able to render litmus milk alkaline, and 760 were varieties of yeast. Oidium lactis was also isolated. The 200 mould growths were species of *Cladosporium* and *Aspergillus*.

Example 4.

In the previous examples it has been demonstrated how butter and other dairy produce can be and are contaminated by bacterial agencies, which undo all the benefits derived from the neutralisation and pasteurisation of the cream. The manufacturing company in each instance had gone to considerable expense in installing and operating a pasteurising plant, and the manager and his subordinates had devoted much time and effort to improving their knowledge in order to manufacture the best quality butter—one that would not only be of choicest grade for immediate consumption, but would remain so after a considerable period of storage. They desired, in fact, to produce a choicest grade article suitable for exporting overseas, or for long storage for winter requirements.

It has been shown how these efforts were rendered unavailing, and that the official butter grade certificates disclosed that the quality had either already deteriorated or was rapidly doing so, in spite of everything that could be thought of to remedy matters.

In each case, however, practical bacteriological examinations, carried out in a thorough and systematic manner, have solved what seemed to the managers most difficult problems. The value to the industry of science thus practically directed in the manufacture of dairy produce has been so clearly demonstrated and put on such a sound basis, that general interest has been created on the part of those employed in dairy produce factories. So great has this interest become, that the Dairy Branch has repeated requests from managers that their factories should be visited for the purpose of similar investigations being carried out. These applications will be acceded to as soon as a favourable opportunity occurs, but meantime these articles (and also lantern lectures based on the results of the examinations therein described) have been the means of awakening those engaged in the manufacture of dairy products to the important part that bacteria take—for good or for the reverse—in the various manufacturing processes that are necessary to the production of high-class butter and other products of milk, all of which may be classed as more or less perishable.

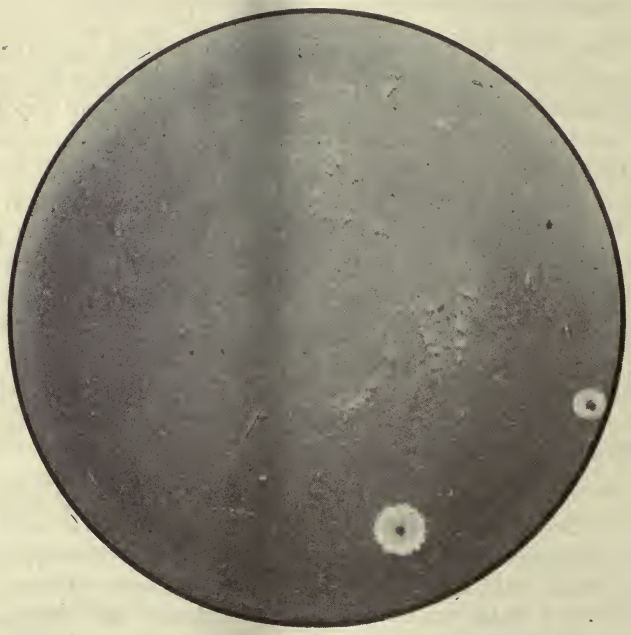
The important part the factory buildings and surroundings play in causing inferior quality has been made evident in each of the examples already given. So far the factories described have been built many years—in two cases they were very badly planned in the first instance for the purpose for which they were intended, and in the first case, neglect had accentuated these bad features until the whole premises had become nothing else than a means for distributing harmful organisms, thereby enormously re-infecting at every stage of manufacture either the cream or butter.

The moral it has been our endeavour to point is the need of the utmost watchfulness and care on the part of those controlling these factories in order to guard against re-infection, and the nullification of all the labour and expense involved in killing the dormant or undeveloped contamination which is to be found to a greater or less extent in every can of cream or milk as it is delivered from the farm to the factory. The dangers arising from the use of bad starters were shown in Example 2, and the need of a pure water supply in Example 3. We have also striven to drive home the need of having properly constructed premises for carrying out the manufacture of an article so susceptible to outside and surrounding influences as milk and its products.

It has been thought that it would be advisable to end this present series of articles with a description of the most modern and best constructed and planned butter factory in New South Wales.

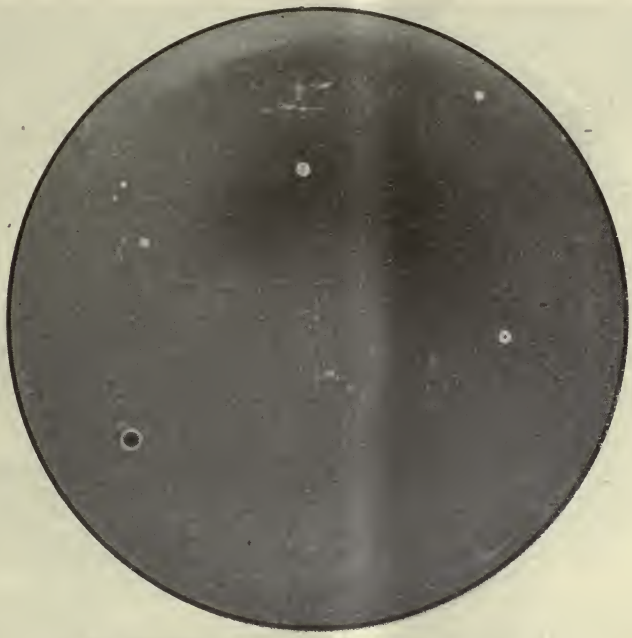
This factory was only opened for use some fifteen months before we made our examination. It was planned to admit the maximum of light, to provide thorough ventilation, and to eliminate, as far as possible, all overhead floors, beams, pipes, &c., which act as collectors and distributors of dust and germs. Much attention was given to the matter of drainage and keeping the inside of the premises clean. The walls in the manufacturing rooms were lined with white opalite tiles, and all woodwork was covered with white enamel paint

Acid Agar Plate, atmospheric exposure for 2½ minutes in the cream receiving room of a modern factory. (Original.)



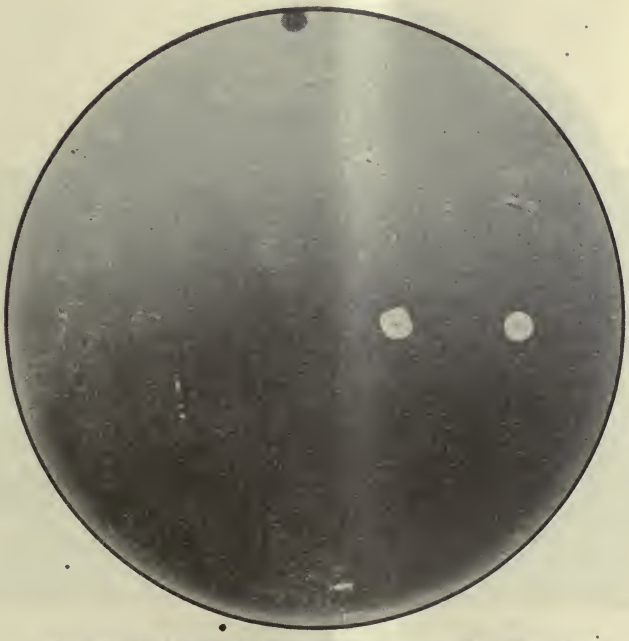
Acid Agar Plate, atmospheric exposure for 2½ minutes in the butter room of a modern factory. (Original.)

D 3



Litmus Lactose Agar Plate, atmospheric exposure for 2½ minutes in the attemperator room of a modern factory. (Original.)

D4

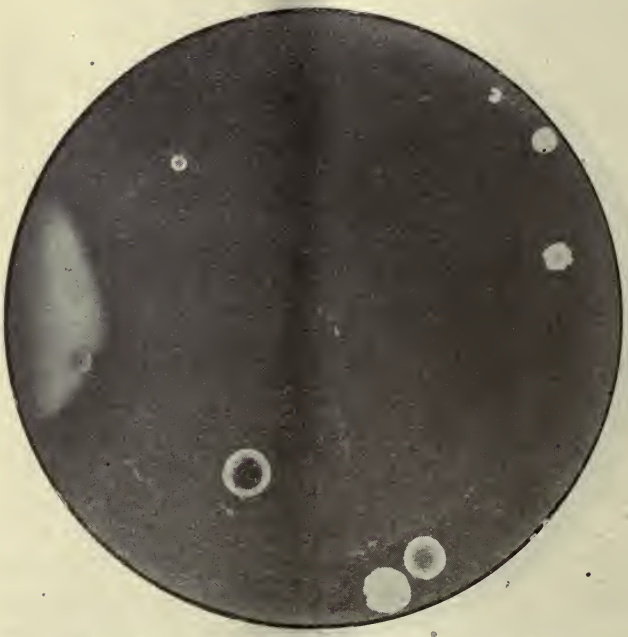


Agar Plate, atmospheric exposure for 2½ minutes in the cheese-making room of a modern factory. (Original.)

D5

Litmus Lactose Agar Plate, atmospheric exposure for 3 minutes in the cold room of a modern factory.

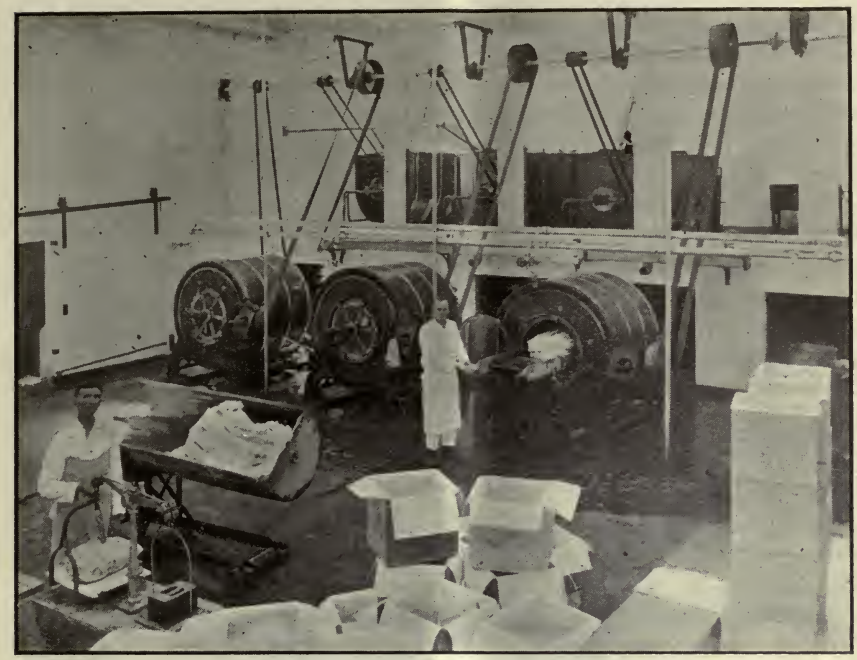
Note the large number of moulds. (Original.)



D 6

Acid Plate Culture of butter wash-water (dilution 1 to 10).

(Original.)



Butter-making Room in a Modern Factory.

Ample provision has been made for light, ventilation, and sanitation.

Cheese-making Room in a Modern Factory.

brought to a high finish. Beside having windows round the walls, light was freely admitted into each room through the roof by means of reinforced corrugated opaque glass sheets; the ceiling, which was also painted with white enamel, followed the contour of the roof, openings being made to correspond with the glass parts, and along the ridges of the roofs ventilators were installed.

A good idea of the whole structure, both inside and outside, can be gathered from the accompanying illustrations. In planning this factory the saving of labour was always kept in view. The total cost came to over £10,000, but the interest on this outlay has been more than met by the saving in labour and the improvement in quality that took place immediately the new premises were occupied. Previous to this it took thirteen men to cope with the work; now—with an increased output—nine are sufficient, with an individual minimum wage of £3 17s. 6d. per week. Further, the change from the old dilapidated factory brought about a simultaneous improvement in the quality of the butter turned out—an improvement worth about 3s. per

A well-planned modern Butter and Cheese Factory on a Northern River

cwt. based on the condition of sales made under the imperial contract. It will be seen that the action of the directors in erecting this modern factory has been fully justified, and it has proved a most profitable undertaking to those engaged in dairying in that district. The factory is ideally situated from the points of view of sanitation and purity of atmosphere. It fronts a tidal river, and is bordered on the other three sides by green fields. The plate developed from a 2½ minutes exposure under the cream vat platform, which is open to and on the same level as the churn room, gave no evidence of moulds or bacteria being present. The methods of making these exposures were similar to those described in previous articles, and the results showed that the premises and surroundings were remarkably free from infection—with one exception. The plate D5—three minutes air exposure in the cold room—shows that this room was much infected with mould. Mould was also found on the timber used for making butter-boxes, having evidently been brought into the factory from the timber mill and box factory. The room where this

timber was stored in shooks, and where the butter-boxes were put together, adjoined the butter-making room, and an exposure made in the current of air flowing between the door from this room to the outlet on the opposite side of the churn room also showed the presence of mould organisms in numbers, while the plates exposed on either side of this draught showed little or no growth—thus demonstrating how the spores were being carried right through the building and out the other side by the wind, after having been disturbed in the box room, perhaps while the infected timber was being shifted or while the different pieces were being nailed together. Possibly the force of the wind off the river was sufficient to lift the spores off the colonies growing on the wood, without the latter being moved at all. The boxes, after being filled with butter, were carried into the cold room and stacked almost to the height of the ceiling. At the time of examination this room was almost filled. In putting the boxes on the tiers, mould spores would be dislodged, and they were in the air at the time the exposure was made, with the result shown in D5. The manager of the factory was notified as soon as possible of what was taking place, and advised to close or re-arrange the connection between the timber storeroom and the manufacturing portions of the building, and to have the cold room emptied as soon as could be arranged so as to thoroughly fumigate it or spray with formalin. He was also advised to destroy the moulds then on the butter-box timber before making up more boxes. It is understood these suggestions have been given effect to.

This is a striking illustration of how easily the newest and best planned dairy produce factory premises may be infected, and shows what an amount of watchfulness and care is necessary to keep everything connected with the manufacture of dairy produce free from sources of contamination. The factory manager must be ever on guard against re-infection.

Water used in Manufacturing Butter.—In the present example the plate D6 indicates a water of unexceptionable purity, judging by the small bacteriological count. This is in marked contrast to other waters examined, notably in Examples Nos. 2 and 3 described in the previous articles. In the present case the water is obtained from a spring near the surface, the current draining rapidly into an excavated reservoir through a bed of water-worn coarse quartz gravel and sand. This reservoir is situated about half a mile from the factory, to which the water is brought through galvanised iron pipes by pumping. Good though this water is, it might be still further improved by filtering, in order to free it from sedimentary matter which will, as time goes on, accumulate more and more in such a length of pipe line.

While on the subject of butter-wash waters, it may be of interest to mention the case of another butter factory which had been in trouble for some time through the bad keeping quality of the product turned out. This is one of the several cases recently investigated and remedied to the satisfaction of the manufacturing company. Samples of water (taken from

the source of supply—a well) were examined and found to be heavily polluted, among other organisms present being members of the coli and proteus groups—evidence of surface contamination.

The manager of the company, on being advised of the results of the first examination, caused shafts to be sunk in various directions round and more or less distant from the factory. Samples of the water thus obtained were sent to the Department, and on examination they were found to be similarly infected to the sample first sent in. On inquiry it was ascertained that this factory is situated in the midst of low-lying swampy country, the underground supplies of water evidently having soaked through the surface soil. The directors of the company have now decided to remove the factory to a site where a purer water supply can be obtained—a commendable step.

A good water supply is an absolute essential to the manufacture of good butter. Now that pasteurisation has been generally adopted in order to kill off or prevent the development of injurious organisms that have obtained access to the milk or cream, it is manifestly the height of folly to allow a fresh infection to take place by washing the butter in the churns with contaminated water. A water-filtering plant should form part of the equipment of every factory. In the majority of cases it would remedy matters; if not, a new and clean supply should be obtained if at all possible. Even if the factory had to be removed, it would be an expenditure well undertaken.

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